

# **DEVELOPMENT OF NZP CERAMIC BASED “CAST-IN-PLACE” PORT LINERS FOR COMMERCIAL DIESEL ENGINES**

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## **ABSTRACT**

Researchers at LoTEC have demonstrated the feasibility of using low thermal expansion, thermal shock resistant sodium zirconium phosphate (NZP) type ceramics [1-3] as insulating port liners in heavy duty diesel engines. This research employed a methodical approach involving finite element modeling (FEM), metal casting, and economic considerations to develop a viable process for fabricating NZP ceramic-based exhaust ports. Preliminary metal casting trials and finite element modeling clearly showed that the relatively weak port liners would be crushed on cooling from the casting temperature due to the large thermal expansion mismatch between the metal and ceramic. The development of a stress-alleviating “compliant layer” resolved the problem allowing the ceramic ports to be cast into metal. Iterations of modeling and metal casting enabled optimization of the material and physical make up of the simple-shaped port liner-compliant layer system to meet design requirements. However, work on complex-shaped port liners and consideration of issues related to their manufacturability, fabrication costs, and in-service durability are immediate needs.

## **1.0 INTRODUCTION**

The exhaust ports of advanced diesel engines of the future will likely be insulated to increase the thermal efficiency of the engine. Increased efficiencies will be possible because the increased exhaust gas temperature going to the turbocharger and the reduced burden on the cooling system will permit smaller radiators and less coolant. An additional benefit of the insulated exhaust ports will be the increased life expectancy of the cylinder head. The insulating (ceramic) material should act as a good thermal barrier and be able to withstand harsh environments and thermal cycling of the diesel engine part [4]. NZP ceramics are leading candidates for diesel engine applications, especially exhaust ports, because of their superior thermal shock resistance (for metal casting) and their low Young’s modulus (for strain tolerance).

The complex shapes of port-liners combined with the need for simple and rapid fabrication processes, require that the metallic cylinder head be cast around a pre-fabricated ceramic liner. In such a casting process, however, thermal expansion mismatch and thermal gradient stresses are present and these vary with the properties of the metal and the ceramic. Because of the pronounced difference in thermal conductivities and thermal expansion coefficients between the